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19. ABSTRACT (Continue on reverse if necessary and identify by block number) The Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC) performs precise orbit computations for Navy Navigation Satellite System (NNSS) satellites, also called TRANSIT, using Doppler observations collected by a worldwide network of stations. Equipment at these sites is configured around either a Tranet II or a Magnavox 1502 DS receiver. Table 1 lists the current stations while Figure 1 shows the tracking network configuration. Recorded Doppler counts, surface weather measurements, and other appropriate data are transmitted via satellite communications or over other telecommunication links to DMAHTC for processing, time corrections, and orbit determination. There are two classes of NNSS satellites -- the "Oscar" and the "Nova". The Nova satellites represent the latest generation of TRANSIT satellites. For Nova satellite 30480 and Oscar satellites 30110, 30130, 30200, 30240, and 30300, data were processed in two-day fits. For Nova satellite 30500, data were processed in one-day fits.			
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**DMA ORBIT DETERMINATION
OF THE
NAVY NAVIGATION SATELLITE SYSTEM
1987**

**J. KENNETH MURPHY
ROBERT J. JONES**



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**DEFENSE MAPPING AGENCY
WASHINGTON, DC 20305-3000**

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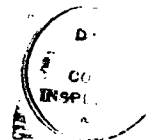
ANNUAL REPORT ON
DMA ORBIT DETERMINATION OF THE
NAVY NAVIGATION SATELLITE SYSTEM
1987

J. KENNETH MURPHY

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DEFENSE MAPPING AGENCY

WASHINGTON, DC 20305-30000



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TABLE OF CONTENTS

	<u>Page</u>
Introduction	1
1987 Tracking Stations (Table 1)	2
1987 Tracking Network (Figure 1)	4
Status Report On Usable Satellites As Of December 1987 (Table 2)	5
TRANSIT Orientation Chart (Figure 2)	6
Ephemerides	7
1987 TRANSIT Ephemeris Availability (Table 3)	9
Summary of Ephemeris Quality (Table 4)	10
Time Stability	11
Satellite Frequency Error Plots (Figures 3, 4, 5, 6, 7, and 8)	13-18
1987 Mean Frequency Stability (Table 5)	19
Polar Motion	20
1987 Polar Motion Processing Scheme (Table 6)	21
1987 Polar Motion Plots (Figures 9, 10, 11, 12, 13, 14, and 15)	22-28
Comparison Of Doppler and BIH Polar Motion 1987 (Table 7)	29
Acknowledgements	30
References	31
Appendix: DMAHTC Pole Position Values 1987	32

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	1987 Tracking Network	4
2	TRANSIT Orientation Chart	6
3	Satellite 30110 Frequency Error Plot	13
4	Satellite 30130 Frequency Error Plot	14
5	Satellite 30200 Frequency Error Plot	15
6	Satellite 30240 Frequency Error Plot	16
7	Satellite 30300 Frequency Error Plot	17
8	Satellite 30480 Frequency Error Plot	18
9	Satellite 30110 Polar Motion Plot 1987	22
10	Satellite 30130 Polar Motion Plot 1987	23
11	Satellite 30200 Polar Motion Plot 1987	24
12	Satellite 30240 Polar Motion Plot 1987	25
13	Satellite 30300 Polar Motion Plot 1987	26
14	Satellite 30480 Polar Motion Plot 1987	27
15	Satellite 30500 Polar Motion Plot 1987	28

LIST OF TABLES

<u>Number</u>		<u>Page</u>
1	1987 Tracking Stations	2
2	Status Report On Usable Satellites As Of December 1987	5
3	1987 TRANSIT Ephemeris Availability	9
4	Summary Of Ephemeris Quality	10
5	1987 Mean Frequency Stability	19
6	1987 Polar Motion Processing Scheme	21
7	Comparison of Doppler and BIH Polar Motion 1987	29

INTRODUCTION

The Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC) performs precise orbit computations for Navy Navigation Satellite System (NNSS) satellites, also called TRANSIT, using Doppler observations collected by a worldwide network of stations. Equipment at these sites is configured around either a Tranet II or a Magnavox 1502 DS receiver. Table 1 lists the current stations while Figure 1 shows the tracking network configuration. Recorded Doppler counts, surface weather measurements, and other appropriate data are transmitted daily via satellite communications or over other telecommunication links to DMAHTC for processing, time corrections and orbit determination. There are two classes of NNSS satellites - the "Oscar" and the "Nova". The Nova satellites represent the latest generation of TRANSIT satellites. For Nova satellite 30480 and Oscar satellites 30110, 30130, 30200, 30240 and 30300, data were processed in two-day fits. For Nova satellite 30500, data were processed in one-day fits. Table 2 and Figure 2 provide additional information on these satellites.

TABLE 1: 1987 TRACKING STATIONS

1502 DS Stations

<u>Station Number</u>	<u>Station Location</u>
30690	Herndon, Virginia
35000	Ascension Island
35004	St. Helena Island
35006	Dhekelia, Cyprus
35010	Diego Garcia Island
35011	Cambridge Bay, Canada
35012	Bahrain, Persian Gulf
35013	Asuncion, Paraguay
35015	Wichita Falls, Texas
35017	Sioux City, Iowa
35018	Shemya, Alaska
35021	Las Cruces, New Mexico
35022	Quito, Ecuador
35024	Sigonella, Italy
35025	Santiago, Chile
35026	Kinshasa, Zaire
35027	Aurora, Colorado
35028	Bangkok, Thailand
35029	Rapid City, South Dakota
35036	Idaho Falls, Idaho
35037	Flagstaff, Arizona
35038	NAS Fallon, Nevada
35039	NAS Meridian, Mississippi
35047	Grissom AFB, Indiana
35048	Hickam AFB, Hawaii

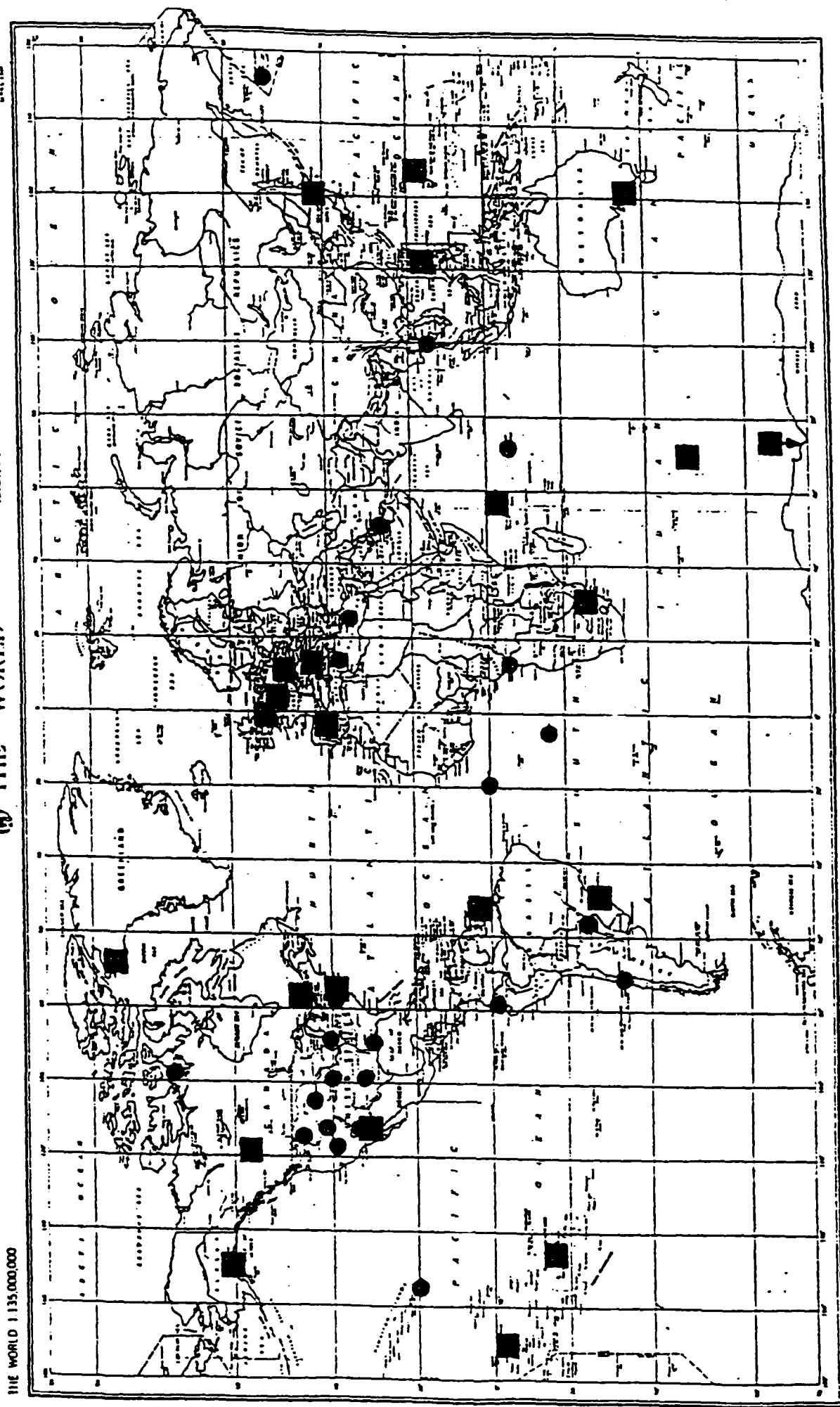
Tranet II Stations

545	Smithfield, Australia
547	Brussels, Belgium
548	Mizusawa, Japan
550	Herndon, Virginia
552	Las Cruces, New Mexico
553	Guam (U.S.)
554	Pretoria, South Africa
555	Sao Jose, Brazil
556	Anchorage, Alaska
557	Thule, Greenland
558	Mahe, Seychelles
559	San Miguel, Philippines
560	Tafuna, American Samoa
561	Austin, Texas
562	McMurdo, Antarctica
563	Calgary, Canada
564	Ottawa, Canada
565	Wettzell, West Germany

567	Kerguelen Island
568	Papeete, Tahiti
569	Toulouse, France
570	Hermitage, United Kingdom
590	San Fernando, Spain
591	Kourou, French Guiana

1114 WUJ 113,000,000

THE WORLD 1,135,000,000



● 1502DS

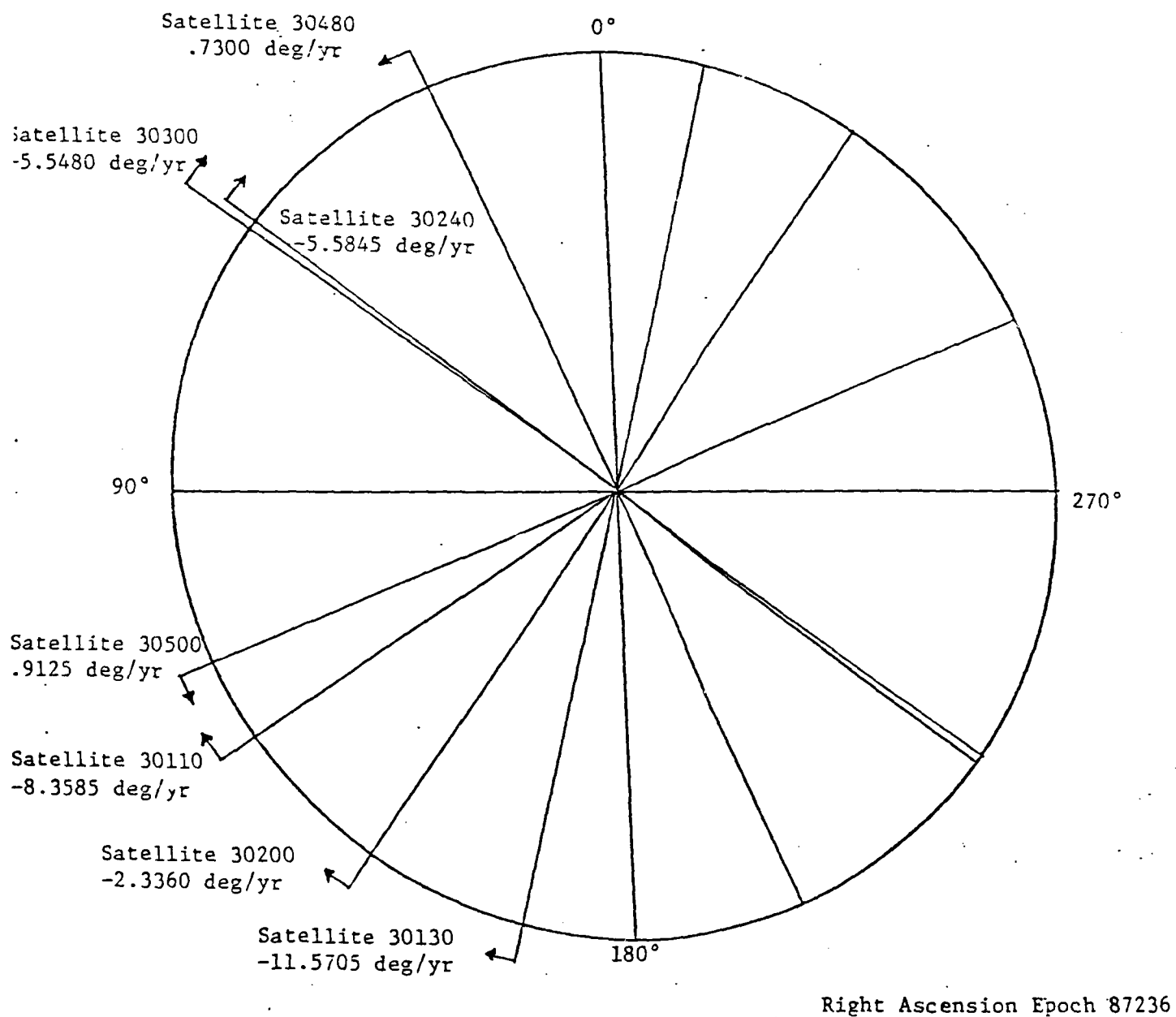
TRANET Network

TABLE 2: STATUS REPORT ON USABLE SATELLITES AS OF DECEMBER 1987

<u>TRANSIT Satellite Number</u>	<u>Launch Date</u>	<u>Status</u>
30110	28 Oct 1987	Operational 121 months
30130	18 May 1967	Operational 246 months
30150	29 Oct 1973	Operational 169 months
30240	3 Aug 1985	Operational 28 months
30300	3 Aug 1985	Operational 28 months
30480	15 May 1981	Operational 76 months
30500	12 Oct 1984	Operational 36 months

These satellites are controlled by the Navy Astronautics Group (NAG) headquartered at Point Mugu, California.

FIGURE 2: TRANSIT ORIENTATION CHART



EPHEMERIDES

Orbits for the six TRANSIT satellites were computed in 1987 on a one-day or two-day basis as previously mentioned, using the CELEST orbit determination program. Ephemerides were computed for the days provided in Table 3.

The orbit computation program provides sufficient diagnostic information to judge the overall quality of estimated ephemerides, the stability of satellite and tracking station clocks, and the performance of the tracking network. One quantity computed within the CELEST program, used as a measure of ephemeris quality, is the station navigation solution. After the satellite ephemeris is estimated, each individual pass of Doppler data acquired during the fit span is used to adjust the geodetic coordinates of the tracking station in directions along and perpendicular to the slant range vector to the satellite at its time of closest approach during the pass. These individual two - parameter station adjustments provide a measure of the consistency of the data with the estimated ephemeris. From these station navigation estimates, a weighted root mean square (RWS) is computed, where the weighting factor for each pass is chosen as the variance of the pass navigation solution.

Table 4 provides the average of the RWS station navigation results for all orbit determinations computed during 1987. These average values, labeled tangential (along - track direction) and radial (slant - range direction), are a measure of the internal consistency of computed ephemerides with the acquired Doppler data.

A measure of orbit repeatability can be obtained by comparing the estimated satellite position at the beginning of each fit span with the estimated satellite position at the end of the previous span. These comparisons are made in the radial, tangential, and normal directions using the satellite position and velocity vectors to define the coordinate system. Averages for these quantities for the year 1987 are found in Table 4 under orbit consistency.

TABLE 3: 1987 TRANSIT EPHEMERIS AVAILABILITY

<u>TRANSIT Satellite Number</u>	<u>Day Number</u>
30110	1-265,267-365
30130	1-365
30200	1-365
30240	189-365
30300	1-259
30480	1-289,295-365
30500	1-365

TABLE 4: SUMMARY OF EPHEMERIS QUALITY

UNITS: METERS

	Satellite 30110			Satellite 30130			Satellite 30200			Satellite 30240		
	Tangential	Radial	Normal	Tangential	Radial	Normal	Tangential	Radial	Normal	Tangential	Radial	Normal
Data Consistency	1.8	1.4		1.4	1.3		1.4	1.4		1.0	0.8	
Orbit Consistency	7.7	3.3	1.0	2.6	0.7	1.4	3.6	0.9	1.3	2.5	1.0	0.8

	Satellite 30300			Satellite 30480			Satellite 30500		
	Tangential	Radial	Normal	Tangential	Radial	Normal	Tangential	Radial	Normal
Data Consistency	0.8	0.7		0.9	0.7		0.6	0.6	
Orbit Consistency	2.3	0.8	0.8	1.9	0.8	1.3	1.3	0.4	0.6

TIME STABILITY

Time stability for the Navy Navigation Satellite System is maintained through the operations of the Naval Astronautics Group at Point Mugu, California. Time is maintained for Oscar satellites through the deletion of cycle counts generated by a satellite crystal oscillator operating at a frequency slightly above a nominal frequency. Fractional frequency fluctuations are compensated for by estimating oscillator instability and by adjusting cycle counts appropriately. An actual time drift will still occur; however, the time error will be maintained within prescribed limits. For Nova satellites time stability is maintained by varying the frequency of the satellite crystal oscillator. This frequency steering occurs daily, as necessary, for satellite 30500 but is not used on satellite 30480 due to a partial failure of the frequency steering mechanism.

As part of the DMAHTC orbit determination solution, satellite frequency bias and drift are estimated. Frequency bias causes a time drift to occur equal to the ratio of the frequency bias to oscillator base frequency multiplied by the effective time span of the bias. Frequency drift causes a quadratic time error equal to the ratio of the frequency drift to oscillator base frequency multiplied by one - half the square of the effective time span of the drift. The long - term frequency stability for the Navy navigation satellites was calculated using the estimated daily frequency bias from CELEST orbit processing. Since this value is readily available on a one-day or two-day basis, long term trends in frequency stability were obtained. Figures 3 through 7 give the plots of estimated frequency bias for Oscar satellites 30110, 30130, 30200, 30240 and 30300 respectively. Figure 8 gives similar results for Nova satellite 30480.

Based on these data, average annual frequency drifts for each satellite were computed and are given in Table 5.

FIGURE 3: SATELLITE 30110 FREQUENCY ERROR

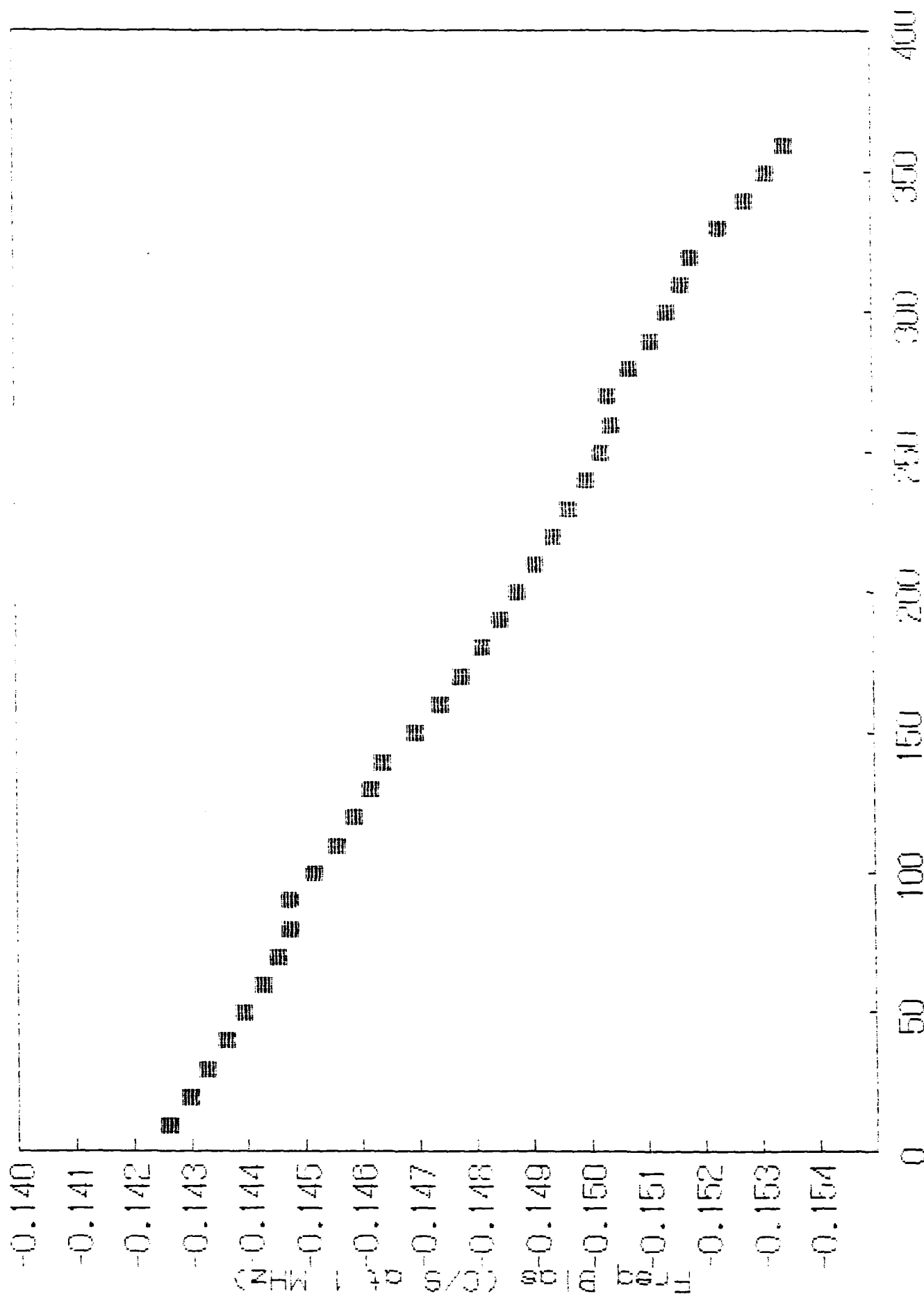


FIGURE 4: SATELLITE 30130 FREQUENCY ERROR

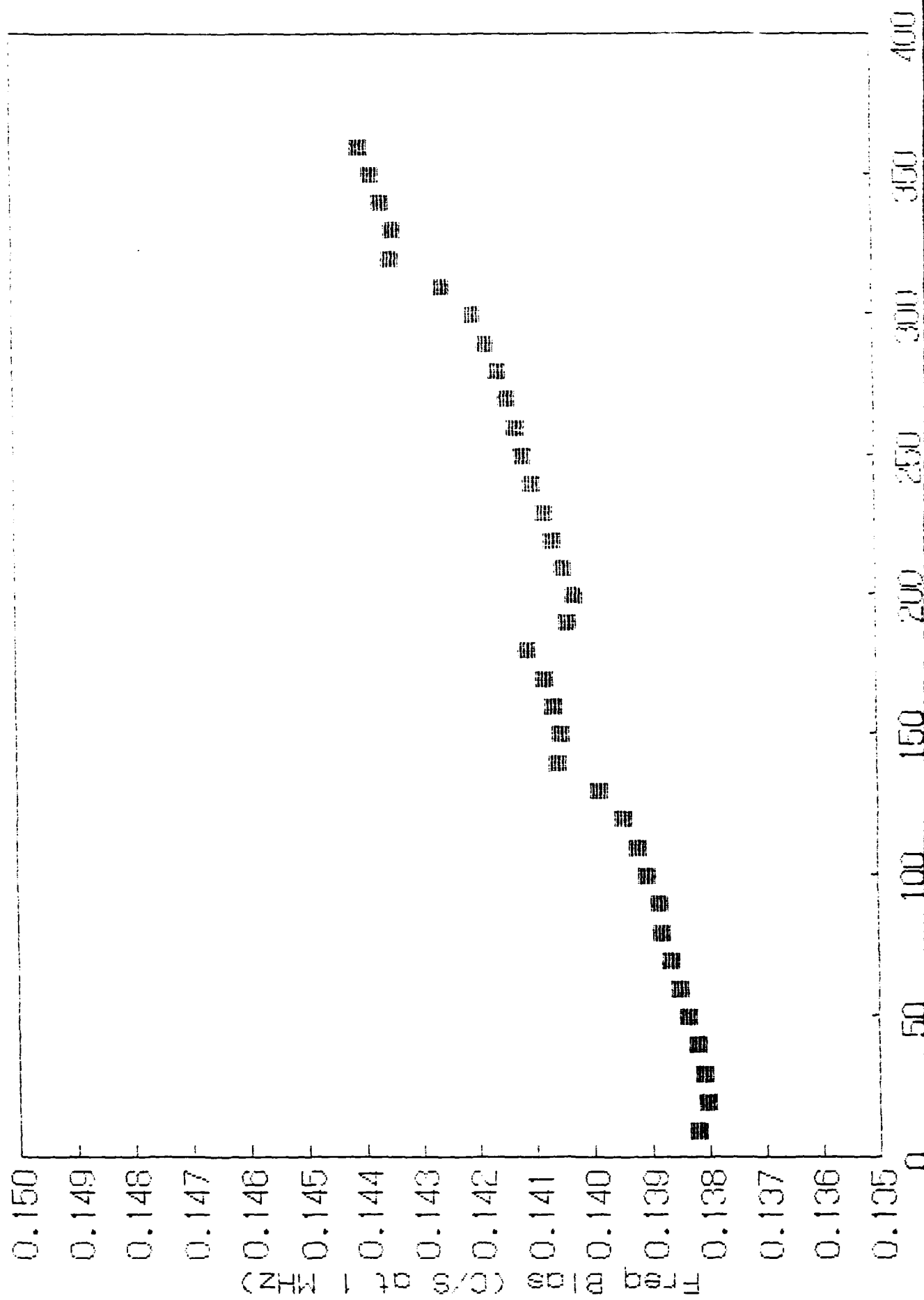


FIGURE 5: SATELLITE 30200 FREQUENCY ERROR

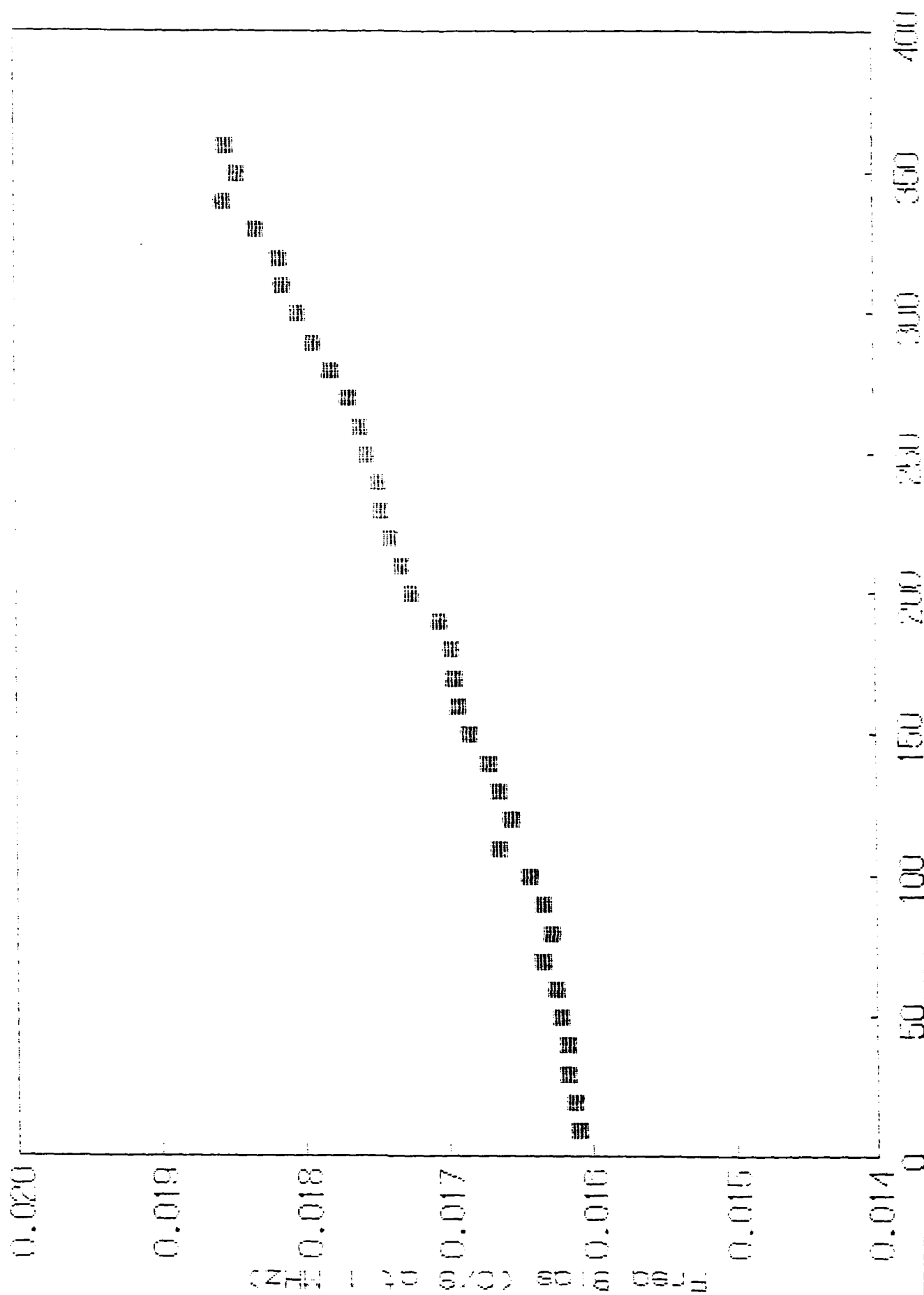


FIGURE 6: SATELLITE 30240 FREQUENCY ERROR

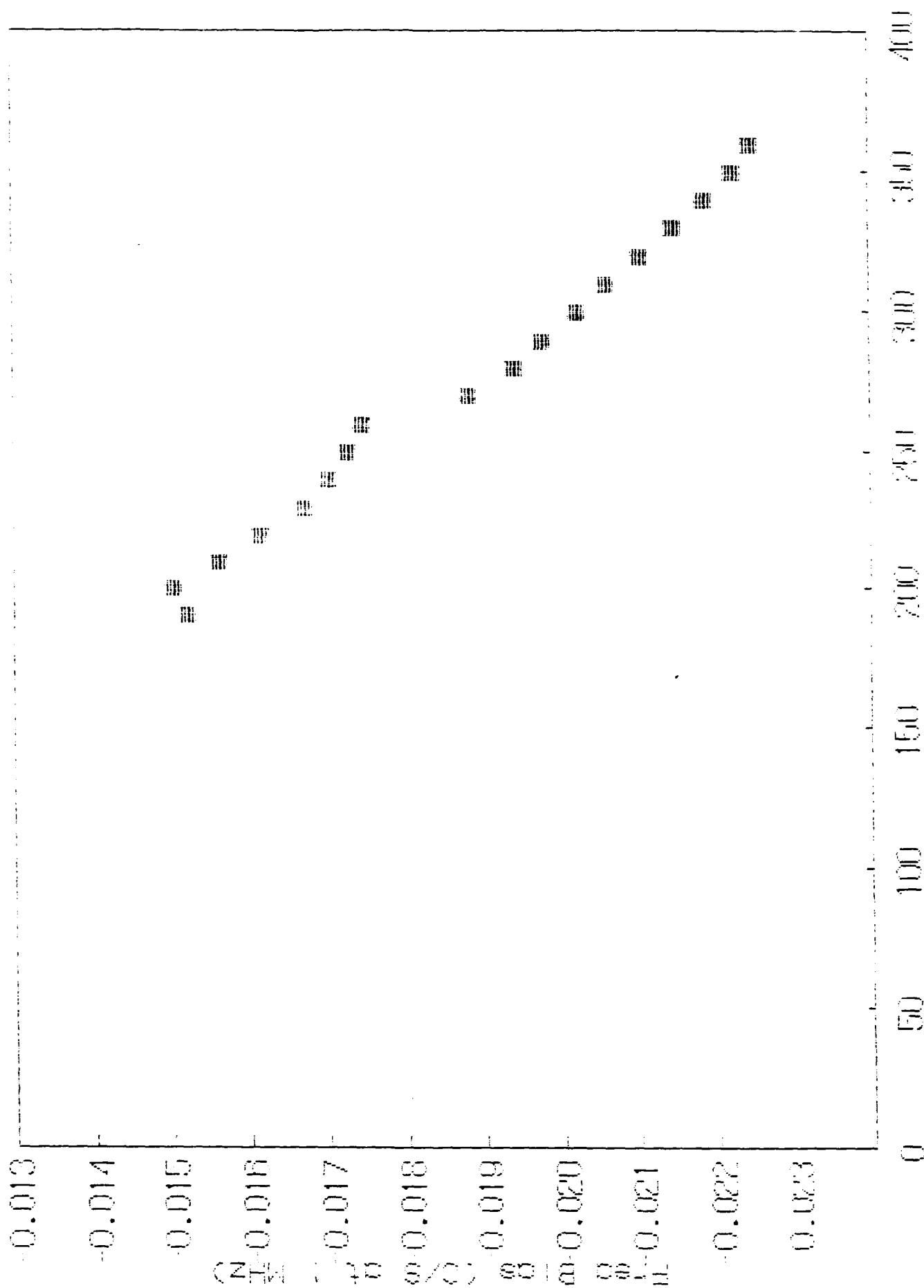


FIGURE 7: SATELLITE 30300 FREQUENCY ERROR

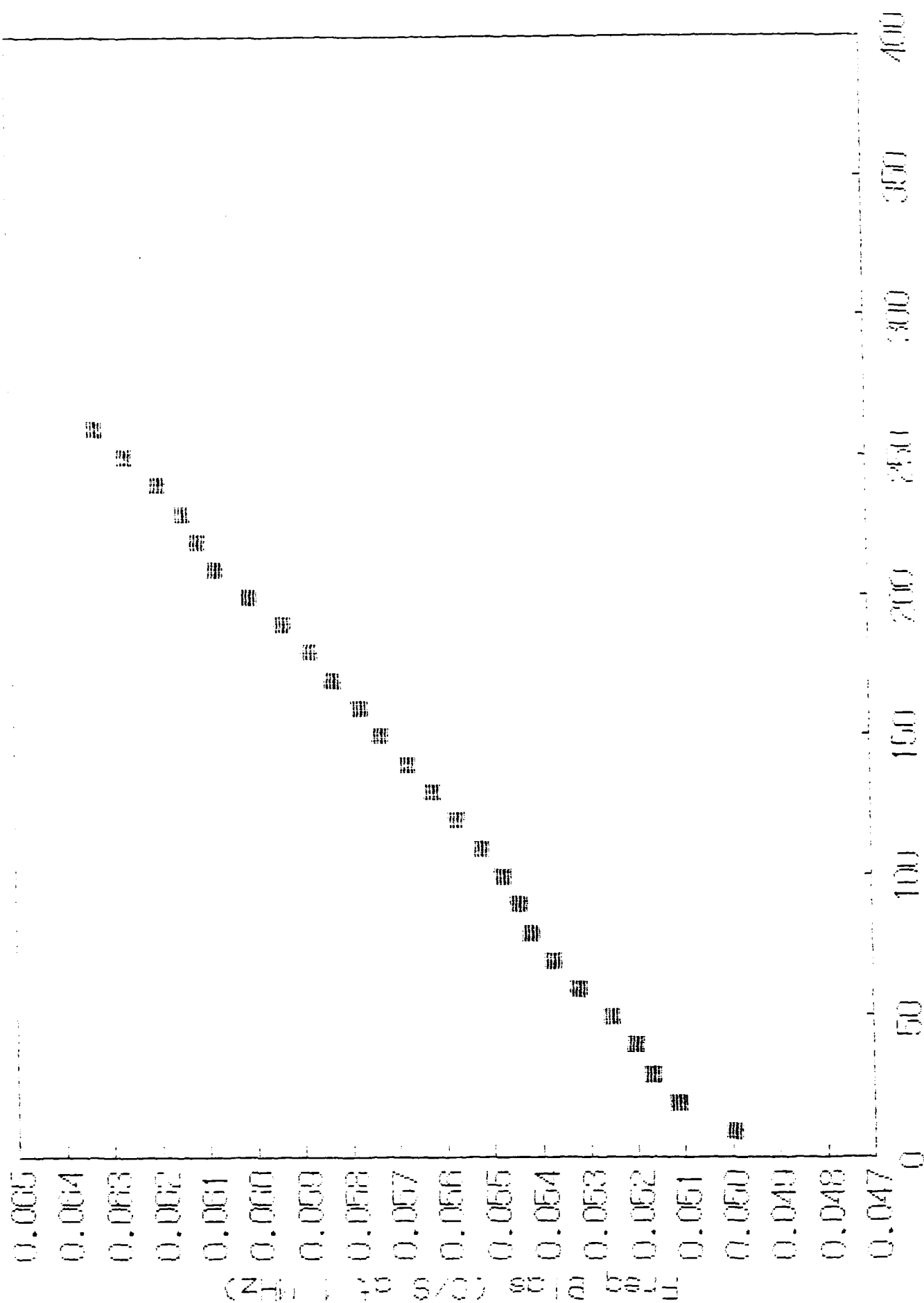


FIGURE 8: SATELLITE 30480 FREQUENCY ERROR

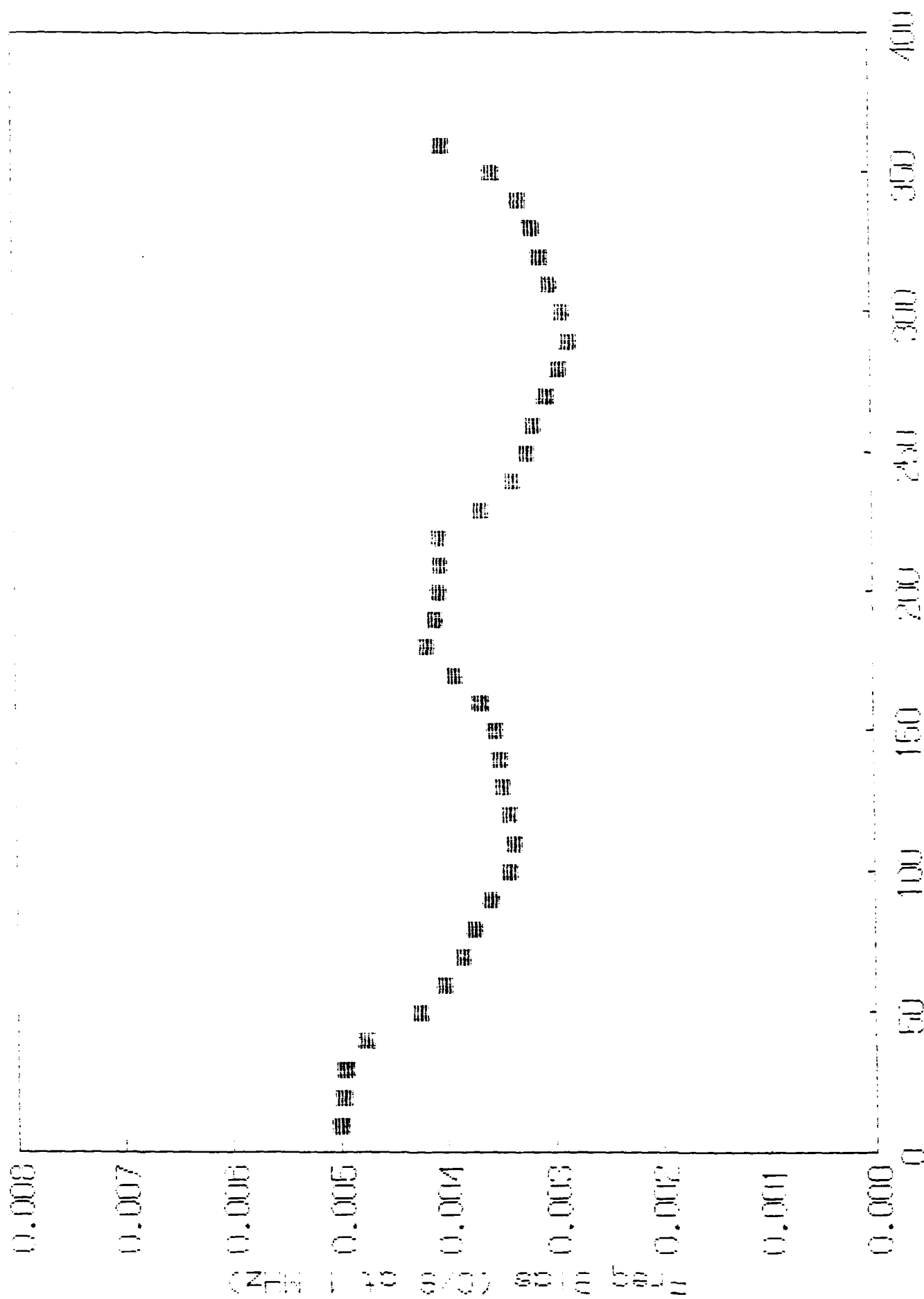


TABLE 5: 1987 MEAN FREQUENCY STABILITY

<u>TRANSIT Satellite Number</u>	<u>Daily Mean Drift *</u>
30110	-30×10^{-6}
30130	13×10^{-6}
30200	70×10^{-7}
30240	-20×10^{-6}
30300	53×10^{-6}
30480	-30×10^{-7}
30500	**

* Units: Cycles per second per day at 1 MHz

** Stability is maintained by active frequency steering.

POLAR MOTION

Included among the parameters estimated in the orbit determination program is the position of the Earth's spin axis with respect to the pole of the adopted Defense Mapping Agency WGS-84 terrestrial frame. The scheme used to compute daily pole values is as follows: each satellite for which two-day spans of data are used for orbit determination is designated to have an odd or even starting day number. Consequently, for each day of the year, pole positions are determined using less than seven satellites. The fit span and two-day designator are provided in Table 6 for each satellite. Satellite data processed daily produce pole position estimates on both odd and even days. Figures 9 through 15 are plots of the 1987 CMAHTC Doppler pole position values for each NNSS satellite. Much of the detail of the plot for Nova satellite 30500 is lost due to the density of data points and their scatter. Table 7 is a comparison of Doppler and BIH polar motion values for 1987.

TABLE 6: 1987 POLAR MOTION PROCESSING SCHEME

<u>TRANSIT Satellite Number</u>	<u>Processing Interval (Days)</u>		<u>Designator</u>
	<u>One-Day</u>	<u>Two-Day</u>	
30300	-	1-259	Even
30130	-	1-364	Even
30200	-	1-364	Odd
30240	-	189-364	Odd
30110	-	1-265 267-364	Even
30480	-	1-289 295-365	Odd
30500	1-364	----	Even, Odd

FIGURE 9:
SATELLITE 30110
DOPPLER POLAR MOTION
RESULTS DURING
1987

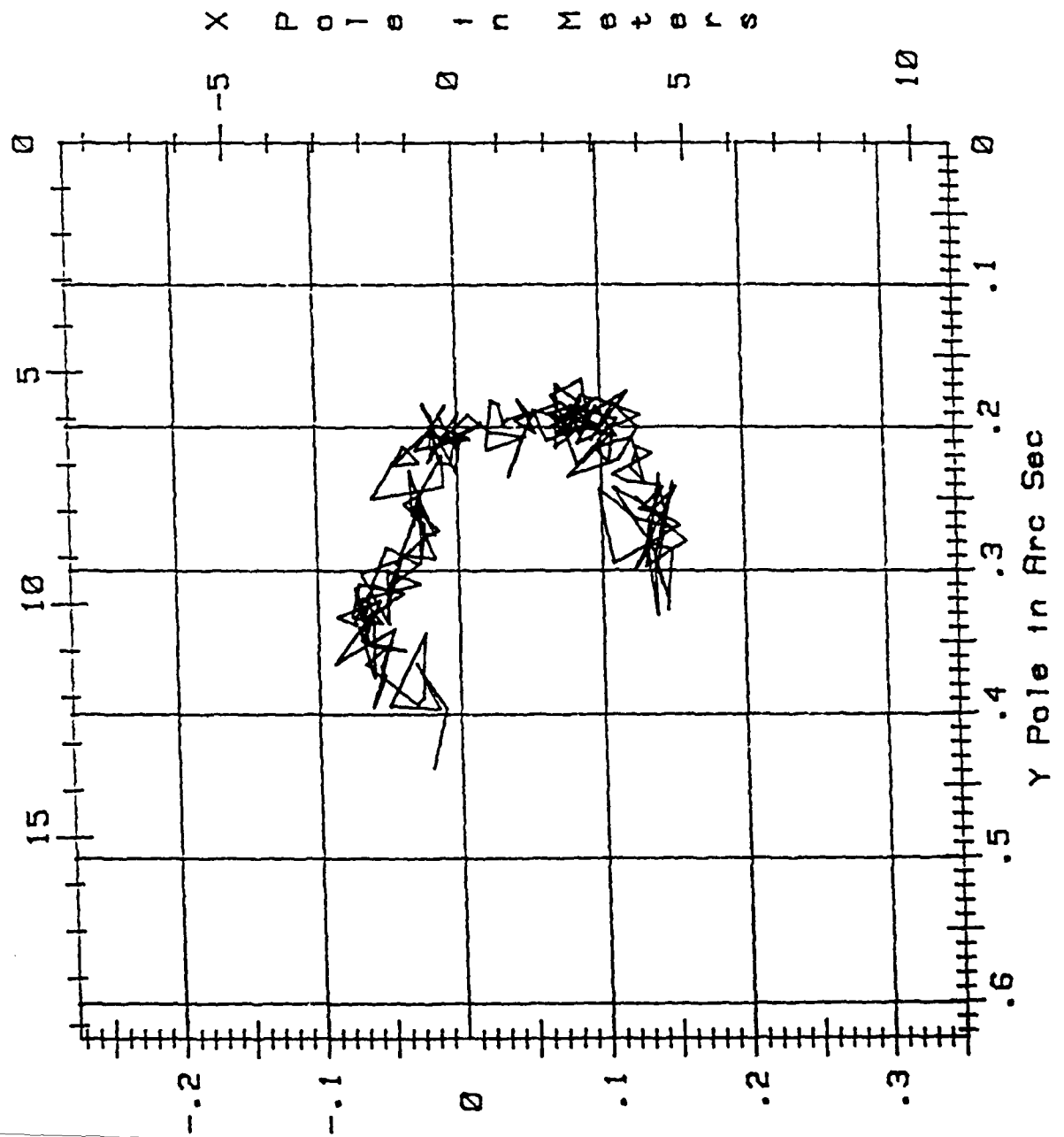


FIGURE 10:
SATELLITE 30130
DOPPLER POLAR MOTION
RESULTS DURING
1987

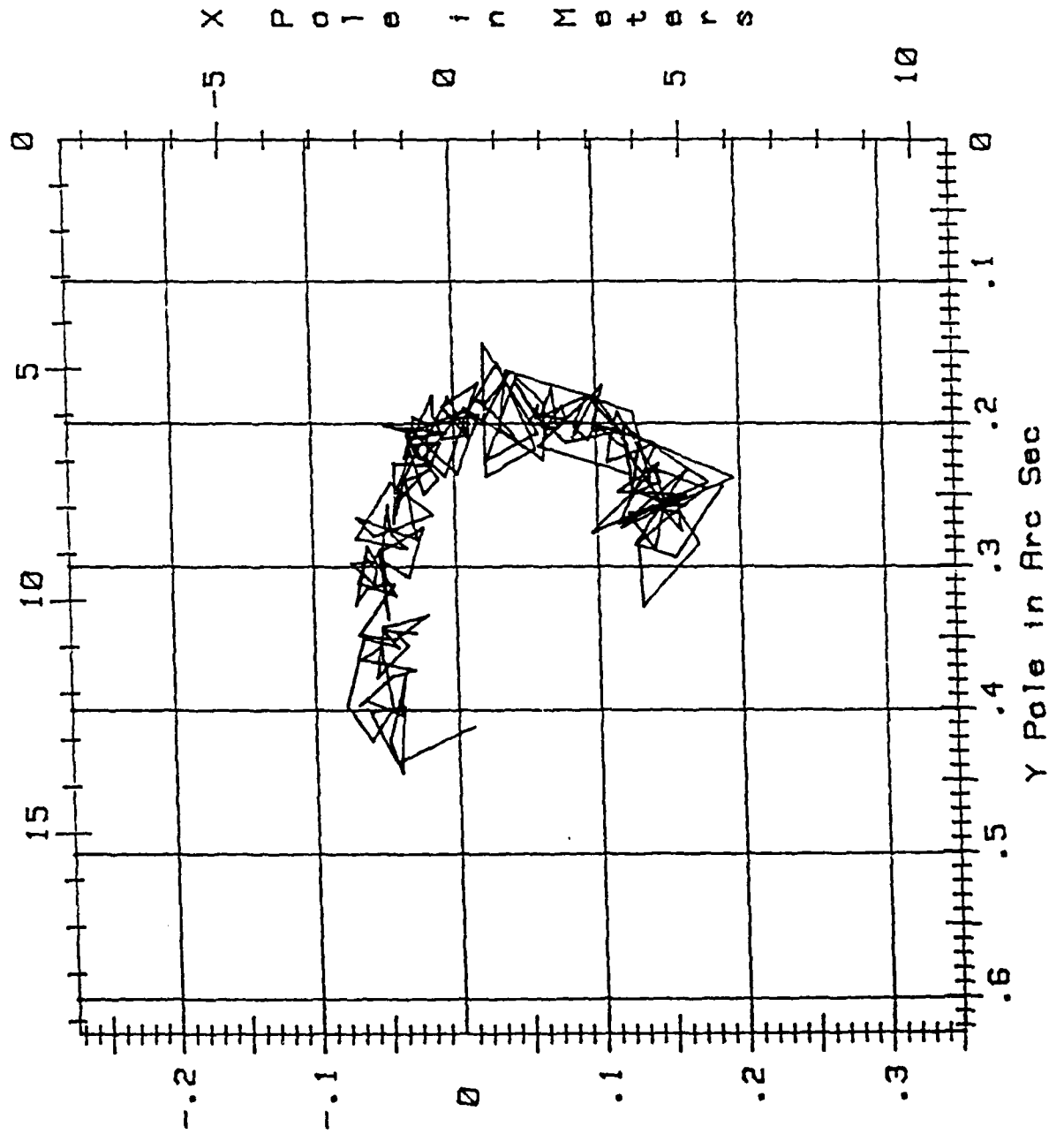


FIGURE 11:
SATELLITE 30200
DOPPLER POLAR MOTION
RESULTS DURING
1987

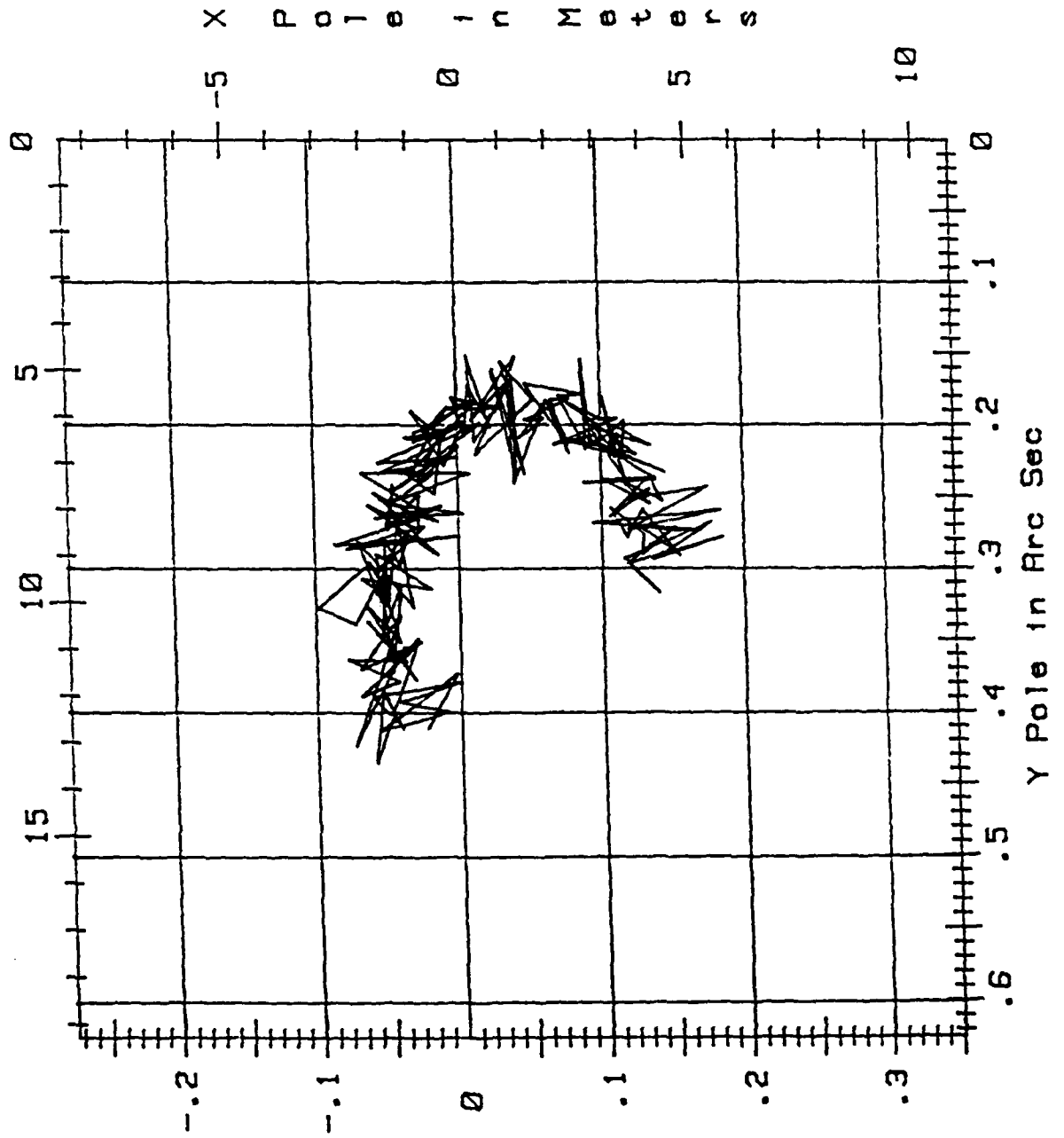


FIGURE 12:
SATELLITE 30240
DOPPLER POLAR MOTION
RESULTS DURING
1987

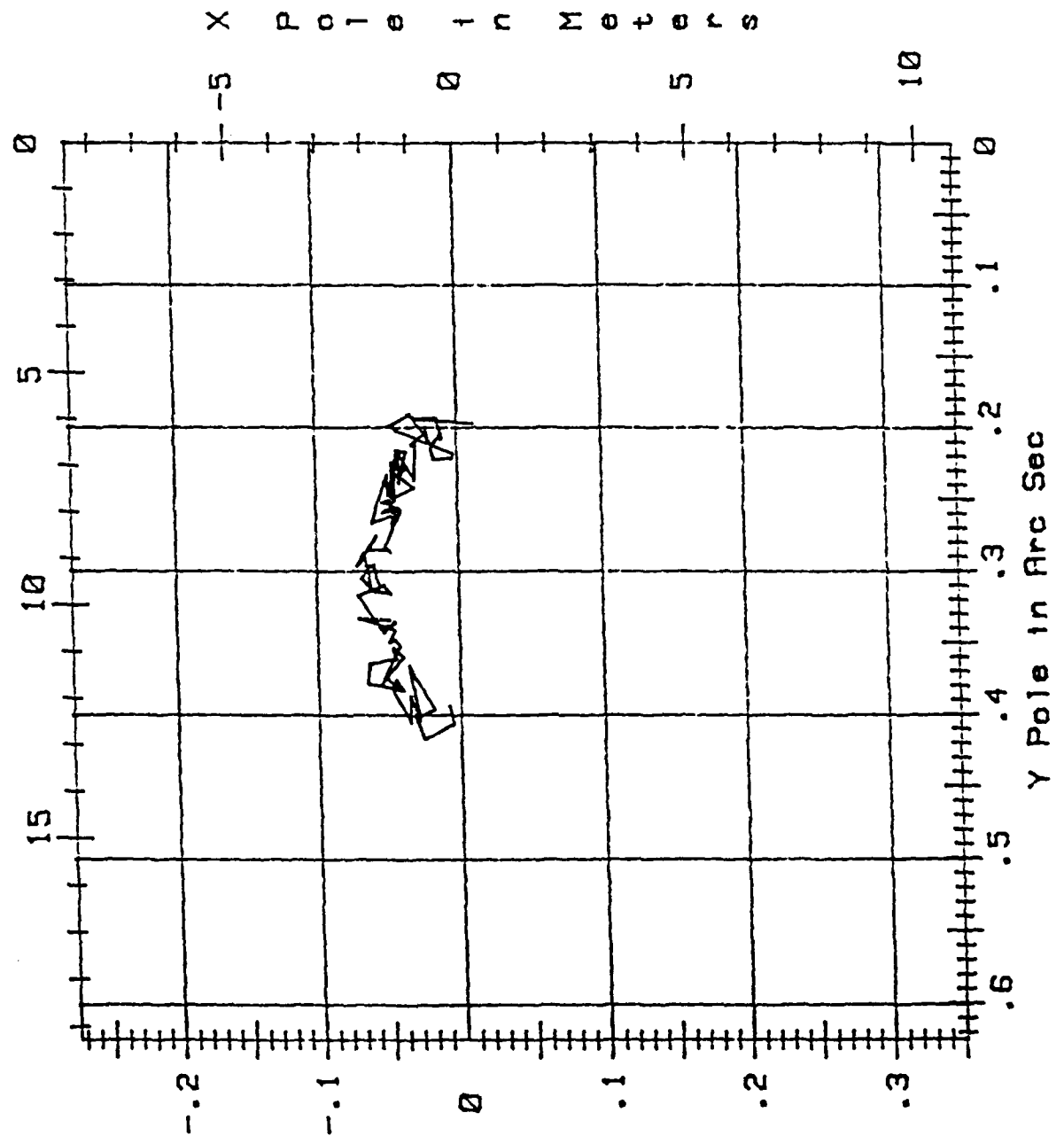


FIGURE 13:
SATELLITE 30300
DOPPLER POLAR MOTION
RESULTS DURING
1987

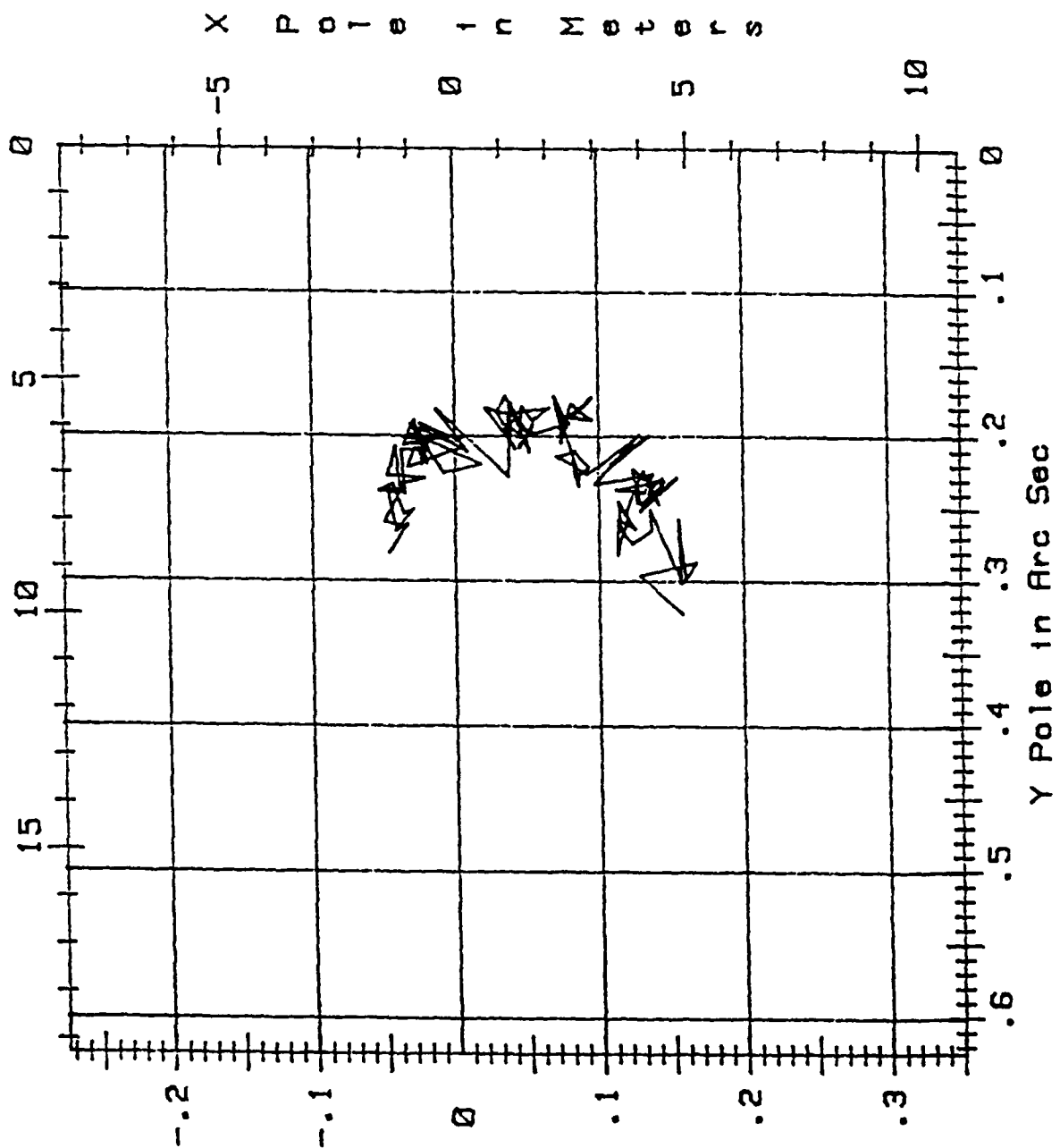


FIGURE 14:
SATELLITE 30480
DOPPLER POLAR MOTION
RESULTS DURING
1987

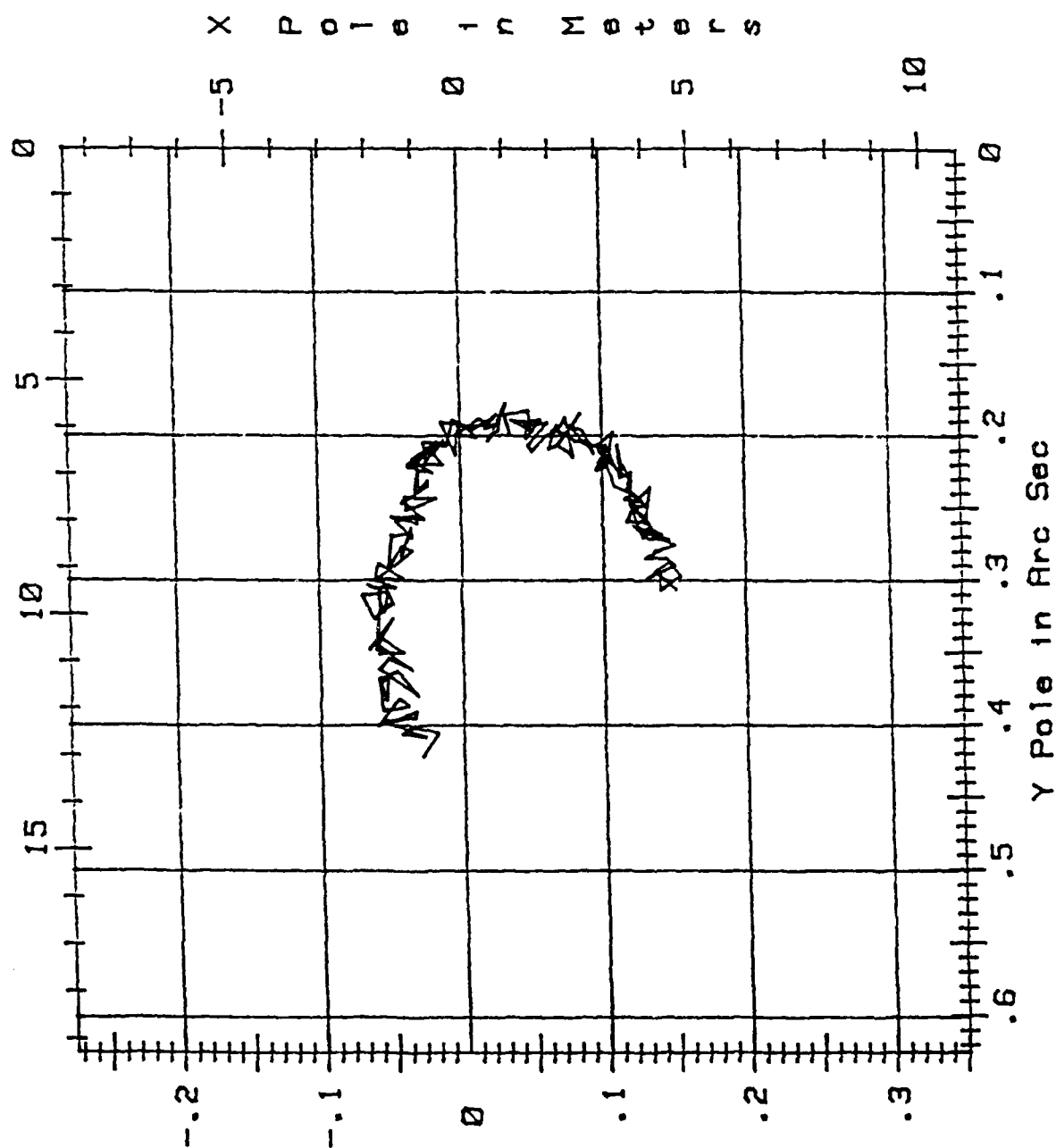


FIGURE 15:
SATELLITE 30500
DOPPLER POLAR MOTION
RESULTS DURING
1987

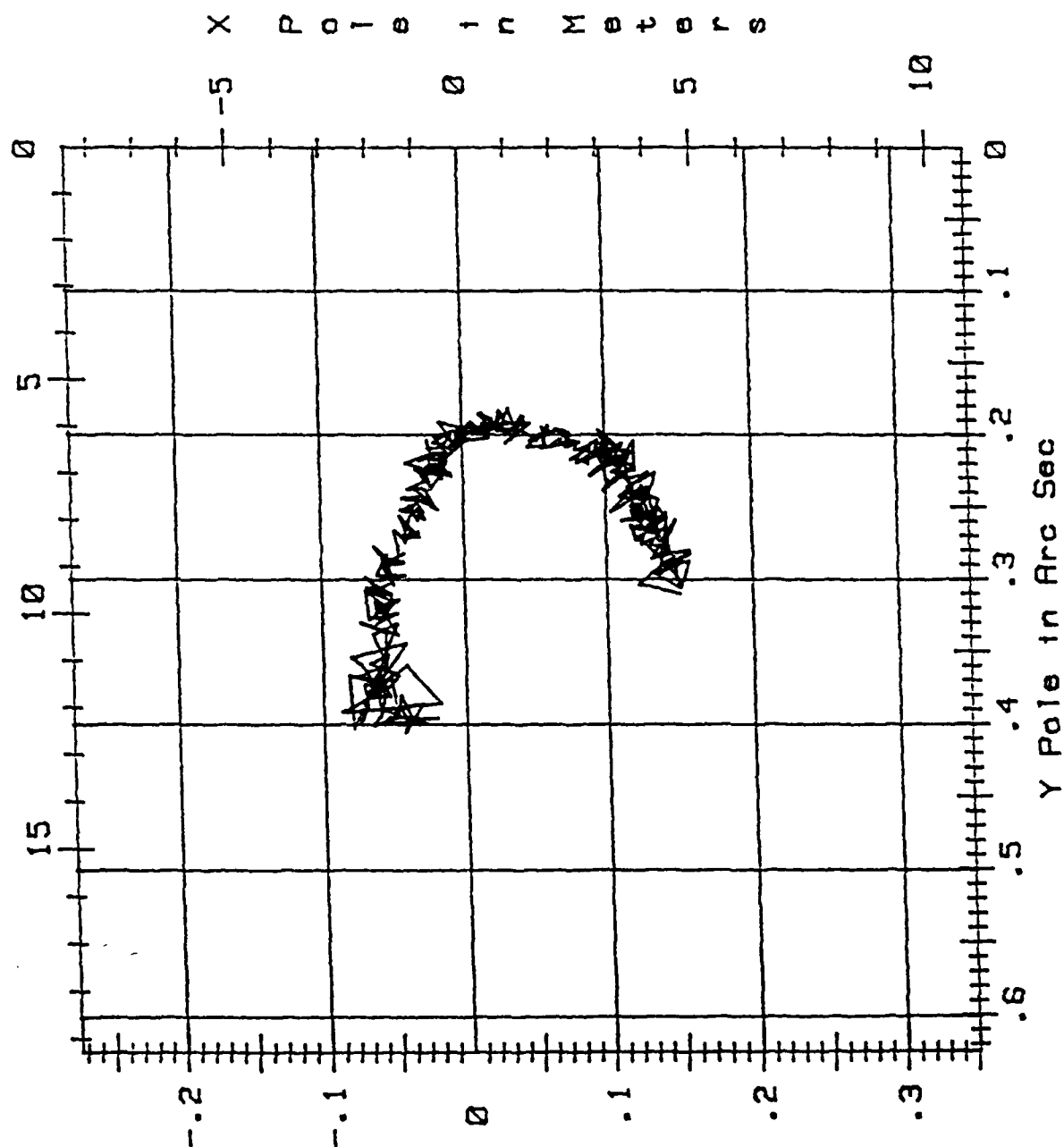


TABLE 7: COMPARISON OF DOPPLER AND BIH POLAR MOTION 1987

<u>TRANSIT Satellite Number</u>	<u>X - Component</u>		<u>Y-Component</u>		<u>Number of Sp</u>
	<u>Mean*</u>	<u>RMS</u>	<u>Mean*</u>	<u>RMS</u>	
30110	.0078	.0183	-.0094	.0197	182
30130	.0093	.0198	-.0138	.0241	153
30200	.0023	.0200	-.0098	.0196	153
30240	.0023	.0104	-.0130	.0170	89
30300	.0021	.0137	-.0119	.0190	129
30480	.0008	.0074	-.0065	.0102	151
30500	.0010	.0090	-.0068	.0119	364

* Mean of Doppler - BIH

Units are in arc seconds.

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Stansell, T. A. (1978): The TRANSIT Navigation Satellite System, Magnavox, Torrance, California.

APPENDIX

DMAHTC POLE POSITION VALUES

1987

DMATC POLE POSITION VALUES
UNITS: ARC SECONDS

		UNITS: ARC SECONDS													
		X POLE (ARCSECS)							Y POLE (ARCSECS)						
YEAR	DAY	30110	30130	30200	30240	30300	30480	30500	30110	30130	30200	30240	30300	30480	30500
87	1	.145	.187	.120		.157	.150	.150	.328	.244	.298		.322	.307	.310
87	2	.149	.154				.139	.146		.285	.317		.296	.296	.284
87	3			.140		.128		.151	.280		.293		.296	.307	.306
87	4	.131	.128				.140	.133	.331	.328			.287	.287	.297
87	5	.138	.131	.115		.167	.154	.151	.291	.284	.268		.298	.297	.305
87	6	.137	.171	.177		.159	.145	.142	.291	.284	.294		.258	.287	.289
87	7	.137	.171	.136		.155	.145	.157	.239	.263	.278		.258	.299	.293
87	8	.150	.159	.185		.157	.130	.136	.296	.261	.297		.301	.290	.280
87	9	.138	.147	.117		.135	.150	.137	.323	.275	.271		.251	.285	.283
87	10	.146	.159	.152		.136	.144	.140	.281	.258	.290		.264	.285	.286
87	11	.134	.157	.129		.123	.129	.142	.298	.256	.275		.275	.285	.280
87	12	.123	.163	.129		.115	.140	.131	.242	.263	.276		.265	.279	.276
87	13	.152	.122	.107		.113	.135	.142	.257	.288	.259		.245	.267	.259
87	14	.136	.140	.129		.125	.129	.136	.233	.258	.291		.264	.266	.284
87	15	.140	.147	.155		.113	.130	.142	.297	.232	.271		.258	.272	.254
87	16	.130	.141	.127		.112	.146	.140	.280	.245	.274		.282	.283	.263
87	17	.159	.176	.155		.120	.131	.140	.249	.285	.271		.257	.271	.259
87	18	.124	.126	.127		.118	.121	.117	.271	.232	.271		.254	.262	.270
87	19	.149	.164	.167		.131	.141	.132	.264	.260	.273		.224	.269	.276
87	20	.123	.130	.094		.138	.131	.136	.244	.273	.268		.240	.263	.266
87	21	.098	.117	.184		.128	.119	.125	.295	.238	.259		.247	.245	.247
87	22	.108	.195	.118		.126	.128	.119	.269	.215	.273		.233	.271	.266
87	23	.155	.141	.174		.126	.134	.143	.242	.270	.243		.246	.263	.257
87	24	.108	.115	.117		.123	.122	.134	.242	.270	.252		.223	.248	.254
87	25	.133	.162	.133		.138	.116	.120	.279	.251	.245		.223	.260	.252
87	26	.133	.115	.106		.144	.130	.118	.264	.248	.264		.234	.259	.259
87	27	.143	.144	.134		.139	.133	.123	.242	.228	.236		.229	.249	.249
87	28					.139	.133	.132	.257	.277			.243	.236	.247
87	29														.264
87	30														.248
87	31														.256
87	32														.254
87	33														.252
87	34														.243
87	35														.249
87	36														.257
87	37														.259
87	38														.254
87	39														.256
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87	41														.243
87	42														.249
87	43														.257
87	44														.259
87	45														.249
87	46														.247
87	47														.264
87	48														.236
87	49														.243

DMAHTC POLE POSITION VALUES
UNITS: ARC SECONDS

		UNITS: ARC SECONDS													
		X POLE (ARCSECS)						Y POLE (ARCSECS)							
YEAR	DAY	30110	30130	30200	30240	30300	30480	30500	30110	30130	30200	30240	30300	30480	30500
87	53			.111		.135	.131	.134			.237		.234	.249	.258
87	54	.140	.119	.134		.134	.127	.125	.240	.202	.255		.246	.246	.239
87	55	.118	.125	.100		.134	.115	.118	.238	.246	.238		.246	.244	.242
87	56	.108	.145	.137		.145	.119	.129	.233	.256	.237		.231	.239	.236
87	57	.135	.127	.088		.142	.126	.104	.218	.229	.241		.238	.241	.253
87	58	.125	.130	.138		.154	.117	.115	.214	.214	.238		.244	.240	.240
87	59	.120	.123	.095		.128	.120	.127	.228	.250	.238		.229	.242	.242
87	60	.129	.144	.144		.140	.119	.134	.214	.214	.241		.251	.244	.236
87	61	.121	.115	.097		.111	.108	.127	.237	.241	.238		.237	.237	.227
87	62	.096	.110	.116		.132	.101	.115	.207	.209	.214		.226	.243	.245
87	63	.105	.107	.115		.138	.120	.102	.225	.227	.222		.231	.226	.230
87	64	.109	.141	.111		.097	.112	.113	.203	.214	.207		.233	.240	.215
87	65	.077	.099	.109		.112	.110	.117	.234	.201	.207		.217	.235	.213
87	66	.112	.120	.101		.108	.114	.106	.223	.217	.197		.226	.215	.236
87	67	.126	.138	.117		.135	.112	.112	.201	.245	.238		.219	.231	.205
87	68	.108	.125	.092		.107	.112	.105	.183	.192	.201		.204	.218	.221
87	69	.093	.096	.135		.128	.102	.116	.209	.182	.201		.199	.206	.236
87	70	.119	.114	.077		.092	.096	.094	.175	.204	.215		.226	.222	.222
87	71	.071	.097	.124		.071	.104	.117	.203	.205	.184		.214	.228	.204
87	72	.092	.105	.074		.083	.107	.108	.201	.173	.210		.211	.207	.219
87	73	.111	.060	.116		.093	.103	.114	.207	.216	.224		.228	.218	.223
87	74	.096	.124	.089		.084	.102	.103	.186	.236	.224		.228	.220	.220
87	75	.083	.121	.111		.082	.081	.094	.212	.214	.196		.216	.209	.205
87	76	.127	.101	.111		.086	.089	.104	.191	.188	.195		.234	.204	.217
87	77	.097	.094	.068		.086	.089	.080	.180	.212	.214		.230	.205	.219
87	78			.094			.094	.093			.208			.212	.203
87	79							.095	.195	.203			.191		.217
87	80							.076							.211
87	81														
87	82														
87	83														
87	84														
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87	101														

DMAHTC POLE POSITION VALUES
UNITS: ARC SECONDS

UNITS: ARC SECONDS																
X POLE (ARCSECS)					Y POLE (ARCSECS)											
AR	DAY	30110	30130	30200	30240	30300	30480	30500	11	30110	30130	30200	30240	30300	30480	30500
7	105			.086		.081	.078	.079	11			.154		.187	.193	.217
7	106	.111	.061				.090	.089	11	.195	.196	.217			.208	.221
7	107	.079	.079	.090		.095	.069	.079	11	.185	.214	.180		.189	.210	.208
7	108			.071		.080	.069	.080	11	.206	.205	.178		.178	.197	.206
7	109	.086	.117	.087			.075	.072	11	.180	.180	.179		.204	.187	.207
7	110	.094	.099			.074	.080	.072	11	.178	.180	.171		.189	.215	.198
7	111	.086	.084	.048		.073	.069	.075	11	.210	.210	.214		.177	.207	.203
7	112	.071	.087	.078		.070	.085	.082	11	.204	.199	.184		.194	.185	.205
7	113	.083	.054	.064		.078	.067	.072	11	.195	.201	.219		.173	.207	.206
7	114	.086	.061	.078		.069	.063	.073	11	.181	.187	.182		.191	.198	.206
7	115	.066	.058	.066		.080	.069	.055	11	.199	.193	.182		.199	.209	.207
7	116	.090	.079	.078		.053	.069	.057	11	.188	.197	.197		.199	.194	.194
7	117	.087	.076	.048		.054	.051	.061	11	.167	.188	.197		.192	.211	.200
7	118	.066	.064	.061		.045	.048	.056	11	.178	.205	.195		.207	.207	.195
7	119	.080	.073	.045		.047	.062	.059	11	.205	.203	.209		.180	.199	.197
7	120	.080	.069	.063		.055	.047	.053	11	.186	.175	.183		.189	.203	.204
7	121	.080	.069	.040		.055	.047	.053	11	.190	.198	.240		.180	.202	.204
7	122	.064	.061	.036		.066	.057	.042	11	.206	.172	.176		.184	.189	.187
7	123	.078	.045	.047		.037	.044	.046	11	.183	.209	.234		.199	.190	.194
7	124	.085	.067	.025		.039	.044	.036	11	.170	.181	.161		.190	.195	.195
7	125	.069	.097	.042		.039	.036	.034	11	.163	.209	.233		.190	.189	.203
7	126	.068	.037	.039		.039	.050	.044	11	.202	.163	.170		.182	.201	.187
7	127	.083	.032	.041		.041	.048	.030	11	.214	.204	.170		.185	.206	.206
7	128	.062	.064	.031		.038	.032	.048	11	.188	.186	.156		.177	.186	.193
7	129	.053	.065	.054		.052	.031	.029	11	.209	.226	.199		.211	.192	.197
7	130	.098	.044	.013		.050	.033	.033	11	.200	.167	.182		.201	.185	.182
7	131	.072	.023	.037		.034	.033	.026	11	.183	.226	.220		.192	.178	.196
7	132			.037			.019	.032	11	.196	.207	.169		.192	.203	.193
7	133							.032	11					.184		.193

		DMAHTC POLE POSITION VALUES													
		UNITS: ARC SECONDS													
		X POLE (ARCSECS)					Y POLE (ARCSECS)								
YEAR	DAY	30110	30130	30200	30240	30300	30480	30500	30110	30130	30200	30240	30300	30480	30500
87	157	.043	.022	.041		.052	.030	.019	.181	.237	.152		.198	.183	.194
87	158			.027			.027	.023	.181	.237	.191			.192	.192
87	159	.052	.058			.042		.031	.193	.218			.188	.192	.199
87	160			.039			.017	.025	.193	.218	.167			.195	.192
87	161	.036	.031			.035		.029	.235	.157			.195		.185
87	162			.012			.026	.021	.235	.157	.212		.195	.185	.186
87	163	.053	.009			.042	.007	.021	.190	.193	.152		.209	.189	.189
87	164			.007				.018	.190	.193	.152		.209	.189	.189
87	165	.036	.020			.021	.004	.014	.194	.201	.202		.181	.194	.193
87	166			.023				.022	.198	.165	.172		.185	.192	.195
87	167	.033	.040			.041	.021	.014	.198	.165	.172		.185	.192	.193
87	168			.007			.021	.014	.184	.185	.208		.178	.188	.196
87	169	.029	.023			.038	.013	.029	.184	.185	.208		.228	.188	.194
87	170			.005		.037	.003	.005	.182	.183	.181		.200	.199	.200
87	171	.024	.016				.003	.014	.216	.193	.181		.182	.200	.198
87	172			.004		.013	.001	.001	.216	.193	.188		.211	.202	.191
87	173	.020	.029				.012	.007	.207	.217	.189		.202	.202	.202
87	174			.031		.009	.002	.019	.203	.189	.185		.192	.193	.204
87	175	.048	.050			.025	.014	.003	.203	.189	.185		.203	.191	.209
87	176			.007			.014	.005	.192	.223	.210		.203	.214	.192
87	177	.023	.007			.002	.004	.016	.192	.223	.210		.200	.214	.198
87	178			.007			.004	.017	.216	.237	.210		.200	.199	.199
87	179	.008	.021			.006	.004	.003	.216	.237	.210		.200	.191	.204
87	180			.030			.002	.003	.216	.237	.210		.200	.191	.204
87	181	.017	.007				.002	.003	.197	.171	.206		.201	.204	.204
87	182					.024	.006	.004	.197	.171	.206		.201	.204	.204
87	183	.017	.018				.006	.014	.197	.171	.206		.201	.204	.204
87	184			.030		.018	.010	.021	.211	.188	.183		.219	.190	.210
87	185	.002	.008				.010	.001	.211	.188	.183		.219	.207	.195
87	186			.013		.008	.010	.009	.216	.210	.233	.197	.226	.207	.210
87	187	.000	.010				.012	.009	.216	.210	.233	.197	.226	.207	.210
87	188			.033	.011		.012	.009	.192	.191	.233	.197	.192	.207	.198
87	189	.013	.011		.030	.031	.012	.014	.192	.191	.233	.197	.192	.207	.207
87	190			.007			.012	.021	.185	.201	.188	.194	.208	.203	.206
87	191	.008	.018		.030	.003	.025	.006	.185	.201	.212	.193	.222	.218	.197
87	192			.030		.033	.027	.018	.216	.196	.212	.193	.222	.218	.205
87	193	.030	.028		.014		.013	.013	.216	.196	.197	.208	.195	.205	.206
87	194			.006	.010	.023	.027	.013	.208	.224	.197	.208	.222	.205	.209
87	195	.009	.035			.012	.013	.025	.208	.224	.228	.204	.195	.206	.206
87	196			.010	.011		.013	.025	.208	.224	.228	.204	.195	.206	.209
87	197	.018	.014		.018	.036	.030	.021	.198	.181	.228	.213	.202	.210	.204
87	198			.032	.018		.030	.021	.198	.181	.191	.213	.202	.213	.217
87	199	.013	.014			.012	.030	.025	.225	.194	.209	.213	.206	.216	.214
87	200			.009	.020		.033	.020	.225	.194	.209	.213	.206	.216	.213
87	201	.004	.008		.033	.028	.017	.031	.226	.211	.209	.213	.190	.204	.218
87	202			.036	.033		.017	.020	.226	.211	.209	.213	.190	.204	.213
87	203	.001	.010		.033	.023	.029	.012	.190	.208	.206	.200	.219	.213	.219
87	204			.011	.048		.029	.016	.225	.182	.210	.218	.201	.223	.223
87	205	.021	.004			.017	.025	.025	.225	.182	.210	.218	.201	.220	.227
87	206						.025	.025							

DMAHTC POLE POSITION VALUES
UNITS: ARC SECONDS

YEAR	DAY	X POLE (ARCSECS)					UNITS: ARC SECONDS					Y POLE (ARCSECS)				
		30110	30130	30200	30240	30300	30480	30500	30110	30130	30200	30240	30300	30480	30500	
87	209			.006	.004	.020	.012	.022			.199	.221	.219	.220	.213	
87	210	.018	.029	.055	.017	.025	.022	.015		.194	.227	.222	.219	.211	.215	
87	211					.025	.022	.024		.184	.207	.203	.197	.226	.226	
87	212	.024	.006	.002	.022	.037	.037	.018		.207	.223	.203	.201	.221	.227	
87	213	.001	.049	.055	.032	.029	.020	.040		.232	.234	.212	.202	.226	.213	
87	214	.003	.027	.016	.029	.019	.026	.023		.208	.198	.211	.202	.223	.228	
87	215	.023	.002	.044	.030	.038	.031	.009		.206	.245	.237	.209	.224	.226	
87	216	.046	.018	.001	.041	.035	.030	.024		.206	.245	.237	.209	.224	.226	
87	217	.027	.035	.029	.041	.039	.026	.034		.206	.245	.237	.209	.224	.226	
87	218	.038	.026	.011	.036	.042	.031	.025		.206	.245	.237	.209	.224	.226	
87	219	.061	.018	.044	.043	.042	.030	.026		.236	.215	.217	.210	.217	.230	
87	220	.010	.018	.040	.046	.047	.030	.026		.194	.215	.217	.210	.217	.234	
87	221	.012	.037	.019	.044	.022	.030	.011		.225	.239	.238	.240	.227	.227	
87	222	.025	.017	.045	.036	.038	.030	.015		.205	.235	.228	.234	.226	.237	
87	223	.033	.010	.008	.040	.037	.024	.024		.222	.206	.217	.234	.229	.229	
87	224	.034	.029	.067	.044	.046	.030	.025		.231	.248	.215	.207	.226	.226	
87	225	.029	.012	.015	.045	.053	.030	.030		.203	.231	.240	.227	.237	.230	
87	226	.033	.010	.045	.036	.038	.033	.028		.242	.248	.215	.207	.241	.227	
87	227	.025	.017	.045	.036	.037	.027	.050		.203	.231	.240	.227	.231	.237	
87	228	.033	.010	.045	.036	.037	.023	.242		.242	.231	.240	.229	.231	.223	
87	229	.025	.037	.019	.044	.022	.025	.220		.241	.235	.228	.229	.231	.231	
87	230	.025	.017	.045	.036	.038	.024	.242		.232	.235	.228	.233	.234	.238	
87	231	.033	.010	.045	.036	.037	.039	.261		.214	.253	.228	.239	.247	.237	
87	232	.034	.029	.045	.040	.046	.041	.231		.215	.234	.232	.239	.243	.238	
87	233	.029	.012	.045	.045	.053	.039	.244		.238	.268	.244	.238	.244	.245	
87	234	.034	.029	.067	.044	.046	.018	.231		.215	.233	.224	.239	.244	.245	
87	235	.034	.029	.067	.044	.046	.040	.231		.238	.268	.244	.238	.244	.245	
87	236	.029	.012	.045	.045	.044	.039	.275		.250	.255	.225	.233	.252	.252	
87	237	.016	.022	.047	.046	.036	.038	.256		.219	.262	.225	.254	.248	.243	
87	238	.026	.031	.047	.046	.036	.026	.248		.245	.262	.251	.254	.244	.244	
87	239	.027	.041	.047	.044	.030	.045	.248		.255	.265	.260	.251	.242	.243	
87	240	.031	.040	.058	.053	.039	.045	.268		.255	.265	.260	.262	.256	.244	
87	241	.031	.040	.058	.053	.039	.049	.268		.255	.265	.260	.262	.256	.244	
87	242	.028	.017	.051	.052	.050	.049	.247		.229	.272	.253	.260	.257	.258	
87	243	.038	.043	.046	.031	.047	.031	.254		.228	.242	.242	.237	.255	.256	
87	244	.023	.043	.046	.031	.047	.032	.268		.270	.230	.230	.265	.259	.252	
87	245	.027	.035	.050	.046	.041	.046	.295		.237	.248	.254	.265	.271	.253	
87	246	.027	.035	.050	.046	.041	.035	.254		.281	.254	.254	.261	.264	.259	
87	247	.026	.027	.028	.048	.034	.038	.254		.273	.256	.256	.264	.264	.256	
87	248			.028	.046	.034	.036	.265		.280					.268	
87	249														.256	
87	250															
87	251															
87	252															
87	253															
87	254															
87	255															
87	256															
87	257															

DMATC POLE POSITION VALUES
UNITS: ARC SECONDS

YEAR	DAY	X POLE (ARCSECS)					Y POLE (ARCSECS)								
		30110	30130	30200	30240	30300	30480	30500	30110	30130	30200	30240	30300	30480	30500
87	261			.015	.043		.043	.032			.291	.260		.284	.267
87	262	.014	.015	.059	.060		.037	.032	.272	.264	.248	.266		.267	.268
87	263							.042							.271
87	264	.031	.046	.028	.049		.050	.041	.256	.242	.265	.233		.269	.263
87	265							.037							.266
87	266		.070	.087	.048		.052	.042		.281	.284	.259		.275	.268
87	267							.047	.292	.288	.277	.257		.271	.266
87	268	.017	.034	.002	.040		.042	.041						.277	.266
87	269							.049	.289	.277	.286	.283		.276	.276
87	270	.041	.045	.078	.051		.035	.048						.280	.287
87	271	.049	.048				.061	.053	.311	.258	.270	.286		.286	.286
87	272			.025	.048		.059	.042		.295	.301	.285		.288	.288
87	273	.029	.053	.056	.052		.042	.047	.296	.308	.274	.285		.289	.289
87	274							.053						.290	.290
87	275	.051	.033	.035	.063		.042	.043	.284		.298	.275		.282	.282
87	276							.053						.287	.287
87	277	.066	.022	.042	.057		.061	.064	.319	.273	.298	.275		.277	.277
87	278							.053						.293	.293
87	279	.028	.054	.052	.071		.065	.050	.309	.290	.280	.297		.304	.304
87	280							.057						.286	.286
87	281	.049	.048	.050	.066		.047	.058	.301	.337	.326	.288		.305	.298
87	282	.050	.052	.043	.061		.060	.055	.301	.285	.268	.313		.301	.301
87	283							.060						.297	.297
87	284	.050	.058	.033	.068		.067	.042	.323	.297	.327	.305		.283	.283
87	285	.050	.073	.070	.062		.052	.055	.292	.298	.281	.296		.302	.302
87	286	.040	.057	.055	.059		.065	.051	.302	.313	.323	.296		.309	.309
87	287	.069	.056	.058	.060			.065						.308	.308
87	288							.054	.337	.303	.290	.296		.309	.309
87	289							.070						.299	.299
87	290	.050	.056	.058	.060			.065	.314	.293	.314	.311		.304	.304
87	291							.052						.311	.311
87	292	.051	.063	.019	.055		.055	.069	.310	.312	.314	.311		.306	.306
87	293	.061	.069	.068	.058		.060	.051						.316	.316
87	294							.052						.310	.310
87	295	.068	.042	.050	.058		.070	.068	.336	.321	.307	.314		.309	.308
87	296							.055	.316	.286	.319	.314		.311	.314
87	297	.068	.063	.050	.058		.062	.055			.296	.316		.327	.327
87	298	.039	.063	.062	.047		.062	.062	.310	.327	.315	.310		.320	.314
87	299							.047						.328	.314
87	300	.071	.071	.065	.053		.049	.068	.333	.315	.315	.310		.308	.308
87	301							.070						.318	.318
87	302	.076	.062	.073	.071		.057	.056	.337	.313	.339	.317		.298	.318
87	303							.052						.331	.318
87	304	.055	.050	.052	.052		.061	.063	.320	.313	.303	.343		.348	.331
87	305							.048			.346	.335		.327	.323
87	306	.068	.043	.054	.045		.055	.063	.336	.348				.337	.327
87	307							.064						.313	.313
87	308													.325	.325
87	309													.325	.325

DMAHTC POLE POSITION VALUES
UNITS: ARC SECONDS

		X POLE (ARCSECS)					Y POLE (ARCSECS)								
YEAR	DAY	30110	30130	30200	30240	30300	30480	30500	30110	30130	30200	30240	30300	30480	30500
87	313			.047	.049		.066	.056	II	II	.372	.334		.348	.337
87	314	.056	.021	.055	.071		.059	.057	II	.321	.308	.333		.339	.359
87	315		.052	.042	.045		.043	.048	II	.333	.351	.341		.350	.338
87	316	.087	.057	.064	.050		.059	.082	II	.343	.326	.350		.351	.330
87	317	.065	.035	.032	.045		.057	.064	II	.337	.377	.348		.347	.403
87	318	.065	.044	.065	.042		.036	.074	II	.313	.337	.352		.362	.366
87	319	.074	.029	.038	.055		.052	.081	II	.353	.364	.379		.354	.359
87	320	.064	.053	.078	.040		.059	.042	II	.356	.363	.360		.379	.354
87	321	.039	.041	.044	.047		.032	.068	II	.345	.337	.352		.344	.344
87	322	.070	.066	.069	.045		.047	.068	II	.347	.337	.352		.362	.379
87	323	.060	.078	.028	.063		.052	.018	II	.345	.364	.379		.386	.359
87	324	.061	.060	.070	.065		.059	.088	II	.345	.363	.360		.354	.373
87	325	.089	.046	.042	.040		.047	.052	II	.357	.379	.353		.362	.366
87	326	.046	.054	.074	.045		.053	.047	II	.350	.379	.353		.380	.359
87	327	.056	.067	.039	.045		.056	.059	II	.375	.333	.383		.367	.352
87	328	.053	.030	.052	.050		.039	.064	II	.341	.389	.361		.363	.371
87	329	.062	.046	.030	.041		.046	.075	II	.368	.351	.365		.367	.371
87	330	.048	.070	.060	.048		.059	.064	II	.372	.370	.375		.368	.367
87	331	.066	.064	.054	.035		.056	.076	II	.365	.354	.381		.360	.360
87	332	.031	.040	.041	.035		.056	.063	II	.372	.374	.376		.374	.374
87	333	.026	.037	.062	.029		.054	.069	II	.398	.370	.379		.383	.372
87	334	.024	.049	.000	.036		.054	.063	II	.365	.374	.376		.387	.387
87	335	.051	.040	.043	.019		.039	.071	II	.355	.333	.383		.367	.399
87	336	.015	.038	.009	.032		.053	.075	II	.372	.423	.375		.369	.369
87	337	.031	.062	.056	.025		.059	.064	II	.372	.375	.375		.382	.369
87	338	.010	.044	.003	.005		.059	.059	II	.365	.354	.381		.390	.372
87	339						.056	.071	II	.372	.374	.376		.380	.382
87	340						.056	.063	II	.372	.374	.376		.387	.394
87	341						.039	.061	II	.373	.374	.376		.387	.394
87	342						.039	.061	II	.395	.349	.383		.382	.362
87	343						.046	.062	II	.376	.349	.383		.380	.380
87	344						.046	.054	II	.397	.349	.383		.382	.382
87	345						.046	.054	II	.397	.349	.383		.382	.382
87	346						.060	.053	II	.350	.435	.381		.367	.367
87	347						.060	.053	II	.366	.386	.405		.394	.394
87	348						.054	.066	II	.394	.386	.405		.390	.401
87	349						.033	.066	II	.404	.386	.405		.390	.390
87	350						.035	.058	II	.394	.411	.387		.397	.397
87	351						.035	.042	II	.389	.389	.404		.395	.389
87	352						.057	.047	II	.374	.389	.404		.398	.380
87	353						.047	.046	II	.421	.389	.404		.400	.400
87	354						.047	.036	II	.344	.379	.366		.401	.398
87	355						.047	.058	II	.395	.379	.366		.398	.398
87	356						.028	.047	II	.443	.393	.396		.408	.387
87	357						.043	.037	II	.397	.393	.396		.389	.389
87	358						.044	.054	II	.398	.400	.402		.386	.386
87	359						.044	.031	II	.401	.400	.402		.405	.405
87	360						.037	.043	II	.365	.413	.417		.402	.394
87	361						.037	.044	II	.365	.413	.417		.402	.400
87	362						.018	.028	II	.396	.373	.406		.405	.397
87	362						.018	.040	II						.395

YEAR	DAY	DMAHTC POLE POSITION VALUES														
87	365	UNITS: ARC SECONDS														
		X POLE (ARCSECS)					Y POLE (ARCSECS)									
		30110	30130	30200	30240	30300	30480	30500	11	30110	30130	30200	30240	30300	30480	30500
							.029		11						.421	

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